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A century of change in global educational inequality between and among genders

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Abstract: Over the last few years, two important phenomena have attracted the attention of social scientists: (i) the uneven global distribution of educational attainment, and (ii) the closing and reversal of the gender gap in educational attainment in favor of women. While it seems clear that these two phenomena are interrelated with one another, no previous study has attempted to investigate and flesh out the nature of that relationship. The main aim of this paper is to bridge this gap by putting together the different types of inequalities into a coherent whole. Our findings suggest that (a) overall educational inequality, as well as inequality among women, have risen together with increasing gender equality, but a decline in both types of inequality can be observed at higher levels of gender equality; and (b) the educational advantage of women over men is gradually becoming an important source contributing to global educational inequality.

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1. Introduction

The last decades have been characterized by an impressive spread of education that has accelerated over time (Barro and Lee 2013) and that is estimated to continue for a long time to come (Lutz and KC 2011). Inevitably, the expansion of education has brought changes in the ways in which educational attainment is globally distributed – with some countries (or certain subgroups within countries) racing ahead and benefiting more than others. Despite their importance, the dynamics of global educational inequality have only recently received some attention, so they are still quite poorly understood. One of the facets of the educational distribution that has received greatest attention both from the media and academia is the gender gap in education. Concomitant with the aforementioned dynamics, we are recently witnessing the emergence of a “global first” phenomenon: the closing *and reversal* of the gender gap in education attainment. For the first time in history, in many high- and middle-income countries, younger women are attaining higher levels of education than men, and the same trend is expected to occur in other countries as well in the coming decades (Esteve et al 2016).

The implications of changing education distributions and the reversal of the gender gap in education are multiple and might go in opposite directions. While increasing education inequality is likely to serve as a wellspring for increases in inequality in many other life domains (higher dispersion in educational attainment is associated with higher dispersion in wages and lower economic growth, occupational mobility, physical and mental health and general well-being – see Dorius 2013, Ballarino et al 2014), the closing and reversal of the gender gap in education in favor of women might lead to more egalitarian attitudes (both in the domestic and public spheres, Esteve et al 2016) and more efficient economic outcomes (Klasen and Lamanna 2009). While it seems clear that the two phenomena are interrelated with one another, no previous study has attempted to investigate and flesh out the nature of that relationship. For instance: Does the reduction – and eventual reversal – of the gender gap in education go hand-in-hand with less educational inequality overall? How does gender inequality relate to differences in education among women or among men? If these two inequalities go in opposite directions, it will be essential to understand whether and under which conditions trade-offs between both policy objectives can be avoided. The main aim of this paper is to address these substantive questions by putting together the different types of inequalities into a coherent whole to better understand if and how they can be simultaneously reduced.

Our empirical analysis covers almost one century of global education expansion: it is based on the latest version of the Barro and Lee (2015) database (henceforth BL) for the period from 1950 to 2010 and on some of our own projections, extending the results up to 2040. The huge geographic coverage of the database (146 countries) allows performing both global and regional analyses over time. Given the ordinal nature of the BL educational attainment indicator and the limited number of available tools to analyze variability for that kind of variables, we develop a specifically crafted inequality measure with nice and useful decomposability properties. Hopefully, the new measure proposed in this paper can be a useful addition to those practitioners aiming at gauging inequality in the context of ordinal

variables. Our findings suggest that (i) overall educational inequality follows an inverted U-shaped trajectory over time; (ii) inequality among men was usually higher than inequality among women until the year 2000 approximately, from then onwards women's and men's educational distributions are equally unequal; (iii) overall education inequality and gender inequality go in opposite directions; and (iv) the educational advantage of women over men has become the most important source contributing to educational inequality for most high- and middle-income countries.

2. Background

It is difficult to underestimate the importance of education for individuals across their entire life cycle. On average, highly educated individuals have higher levels of employment, better-paid jobs, a lower risk of being poor, longer life expectancies and higher levels of subjective well-being (see Dolan et al., 2008; Meara et al., 2008; Tilak, 2002). Indeed, education is one of the most important stratification variables of demographic behavior (see Lutz, Butz and KC 2014). For these reasons, the education expansion that has been sweeping the world during the last decades is to be highly welcomed. This expansion includes rising literacy rates (Crafts 2002) and increases in schooling enrollment rates and in completed years of primary, secondary and college education (Benavot and Riddle 1988, Benavot et al. 1991; Meyer, Ramirez, and Soysal 1992; Ramirez and Meyer 1980; Barro and Lee 2000; Cohen and Soto 2007; Morrisson and Murtin 2009). Regarding college education, by 1970, 6.4% of the world's population aged 25-29 had obtained a college degree. Three decades later, this proportion had increased to 13%, and the expected figure for 2050 is 29.4% (KC et al. 2010).

A notable feature of the aforementioned expansion process is the closing and reversal of the gender gap in education. The expansion of college education, for instance, has not been gender neutral (Dorius and Firebaugh 2010; Dorius 2013; Grant and Behrman 2010). Despite initially favoring males, the gender gap has closed rapidly in recent years and, in many countries, even reversed in favor of women (Esteve, Garcia and Permanyer 2012), a trend that is expected to continue over the next decades (KC et al. 2010; Lutz and KC, 2011). In 1970, men represented 63.6% of the total college educated population. This percentage decreased to 52.6% in 2000 and it is likely to reach 44% in 2050, with most high-income countries reaching lower levels (KC et al 2010).

While some authors have analyzed the ways in which the expansion of education has been distributed across and within countries (i.e. they study global education inequality, see Castelló and Domenech 2002, Benaabdelaali et al. 2012, Dorius 2013, Meschi and Scervini 2013, Morrisson and Murtin 2009, 2013 or Jordá and Alonso 2016) and others have documented the closing and reversal of the gender gap in education and investigated its potential consequences (see Esteve et al 2012, 2016), no attempt has been made so far to bridge these two issues into a coherent whole. Even if there are good reasons to believe that these two important phenomena should be mutually related, there is currently no empirical evidence documenting the kind of relationship that might exist between them. This is the main aim of this paper. Inter alia, we aim at investigating whether the reversal of the gender gap in favor of women goes in tandem with reductions in overall education inequality or with

increases in education inequality among women or men. If it turns out that these different types of inequalities go in the same direction it will be possible for decision-makers to reduce them simultaneously. Otherwise, research is needed as to whether and under which conditions trade-offs between policies addressing both types of inequalities can be avoided.

3. Methods

In this paper we treat educational attainment as an ordinal variable. This is a non-trivial decision with important implications that stands in sharp contrast to previous studies on education inequality across individuals². There are several reasons why we have made this decision. On the one hand, cardinal variables like ‘years of schooling’ can be a poor proxy of the substantive type of education individuals might have received and their interpretation can be biased because of the existence of repeaters. In addition, they are quite prone to measurement error due to recall bias. On the other hand, ordinal variables are much less prone to measurement error. The meaning of the ordinal variable categories (e.g. attaining primary, secondary or tertiary education) is reasonably comparable across countries and over time – as opposed to what happens with ‘years of schooling’, which depends on education-cycle durations.

The major disadvantage of using ordinal variables is that their variability cannot be ascertained with well-known inequality measures, like the Gini coefficient or the Theil index among many others (indeed this is *the* key reason why education inequality studies have always relied on cardinal variables). One of the contributions of this paper is to partially fill this gap enlarging the practitioner’s toolkit by proposing a new inequality measure specifically designed for ordinal variables.

A new measure of education inequality for ordinal data

The tools available to assess inequality are substantially reduced when working with ordinal variables (the main reason being that the notion of ‘mean’ – which is crucial in the definition of cardinal inequality measures – is not meaningful in the ordinal case; see Allison and Foster 2004). In this section we propose a new measure of inequality for ordinal variables that has nice decomposability properties. Assume we are working with k education categories in a population of size N . Let N_i denote the number of individuals in the population with educational attainment i (with $1 \leq i \leq k$) and let $p_i = N_i/N$ be the corresponding population share. We define our ordinal inequality measure as

$$I(p_1, \dots, p_k) := \sum_{i=1}^{i=k} \sum_{j=1}^{j=k} p_i p_j \mathbb{U}(i, j) \quad [1]$$

² Studies like Castelló and Domenech (2002), Benaabdelaali et al. (2012) or Jordá and Alonso (2016) cardinalize the Barro and Lee dataset using different techniques (the first two estimate the average length of each education cycle while the last one fits a continuous distribution to capture ‘within-cycle variations’). Others, like Meschi and Scervini (2013) or Morrisson and Murtin (2009, 2013), work with the variable ‘years of schooling’.

where $\mathbb{U}(i, j)$ takes a value of 1 whenever $i \neq j$ and 0 otherwise. This index measures the probability that two randomly chosen individuals have *different* education attainments. Whenever all individuals have the same educational achievement (i.e. $p_i = 1$ for some category i) there is no inequality, so $I = 0$. For any other distribution, I takes strictly positive values³.

It turns out that our index for ordinal variables is intimately related with two other classical measures of heterogeneity defined in the context of nominal and cardinal variables respectively: the ‘index of fractionalization’ and the ‘Gini coefficient’. Indeed, all three measures have much in common because they are grounded in the same basic principle: two individuals are picked at random and one inspects whether (or to what extent) they share a given characteristic/attribute. The only difference between the nominal, ordinal and cardinal cases is the metric that is used to assess the similarity between pairs of individuals. In the nominal case one inspects whether the two individuals belong to different pre-specified groups or not, in the ordinal one whether their (ordinal) attainments are higher or lower and in the cardinal case one takes into account the distance between the corresponding (cardinal) attainments. Not surprisingly, all three measures have an extremely similar functional form⁴.

A nice feature of the ordinal inequality index suggested here is that it is nicely decomposable when the population is partitioned in different groups. In this paper we consider the partition of the population between women and men (N^f and N^m denote their corresponding numbers), but any other population partition in an arbitrary large number of groups would do as well. Let N_i^f, N_i^m be the number of women and men with educational attainment i ($N_i^f + N_i^m = N_i$). Their relative shares are denoted as p_i^f, p_i^m . It is straightforward to check that our inequality index can be decomposed as

$$I = s_f I_W^f + s_m I_W^m + s_b (I_B^f + I_B^m) \quad [2]$$

where

$$I_W^f = I(p_1^f, \dots, p_k^f) \quad [3]$$

$$I_W^m = I(p_1^m, \dots, p_k^m) \quad [4]$$

$$I_B^f = \sum_{i=2}^{i=k} \sum_{j<i} p_i^f p_j^m \quad [5]$$

³ The index is maximized whenever the population is evenly spread out across all education categories (i.e. $p_i = 1/k$ for all $i = 1, \dots, k$).

⁴ The fractionalization index for nominal variables can be written exactly as in equation [1] and the Gini coefficient can be written as $\sum_{i=1}^{i=k} \sum_{j=1}^{j=k} p_i p_j |(y_i/\mu) - (y_j/\mu)|$, where y_i is the value of the cardinal variable one is interested in for group i and μ is the mean of the distribution. In this respect, our index I can be thought as the ‘missing link’ between the index of fractionalization and the Gini coefficient.

$$I_B^m = \sum_{i=2}^{i=k} \sum_{j<i} p_i^m p_j^f \quad [6]$$

$$s_f = N^f(N^f - 1)/N(N - 1) \quad [7]$$

$$s_m = N^m(N^m - 1)/N(N - 1) \quad [8]$$

$$s_b = 2N^f N^m / N(N - 1) \quad [9]$$

I_W^f and I_W^m are the inequalities within the groups of women and men respectively, I_B^f , I_B^m the inequalities between women and men favoring women and favoring men respectively, and s_f, s_m, s_b represent the relative weight of each component depending on the population size of each group. Observe that the between-group component I_B^f (resp. I_B^m) measures the probability that a randomly selected woman has higher (resp. lower) educational attainment than a randomly selected man. Therefore, I_B^f and I_B^m can be interpreted as women's educational advantage over men and vice versa. Using the additive decomposition formula shown in [2] it is straightforward to assess the contribution of each of the four components to overall education inequality.

Remark: Equation [2] can be seen as the ordinal equivalent of the ‘weak decomposability property’ recently proposed by Ebers (2010) for the study of income distributions where a population is split in two (or more) groups. In that paper, a ‘weakly decomposable inequality index’ is defined as a measure that can be written as the sum of the inequality within groups plus a between group component based on the pairwise comparison of incomes for individuals belonging to different groups (see Ebers 2010 for details). Essentially, this is what equation [2] is about: we have within- and between-group components, both being based on the pairwise comparisons of educational attainments. It should be pointed out that ‘weak decomposability’ differs from ‘strong decomposability’: the classical additive decomposition of inequality in within- and between-group components employed for generalized entropy measures like the Theil index or the Mean Log Deviation (see Shorrocks 1980). In that kind of decomposition, the classical between-group component is the inequality that would be observed in a hypothetical distribution where each individual had the same educational attainment as the *mean* in his group. Yet, in the context of ordinal variables the notion of ‘mean’ is not applicable, so the ‘strong decomposability’ property is of no use and we resort to its weaker counterpart. To illustrate the difference between both approaches consider a hypothetical scenario where the number of women and men and their educational attainments turned out to be exactly the same. If educational attainment were measured with a cardinal measure, the between-group component for a strongly decomposable measure would go to zero because the gender-specific means would be the same. If educational attainment were measured in an ordinal scale (as is done here), the between-group component for a weakly decomposable measure would amount to 50% because half of the education comparisons between pairs of randomly selected individuals would involve a woman and a man. These fundamental differences should be taken into account when interpreting the results.

Using the previous notation, the extent of gender (in)equality in a given society will be measured as $G := I_B^f / (I_B^f + I_B^m)$, a measure ranging from 0 to 1. If $G = 0$, there is no woman whose educational attainment is higher than that of any man, and if $G = 1$, the reverse is true. When the education distributions of women and men are identical, $G = 1/2$. This measure is not monotonic: values above $1/2$ reflect a better state of affairs for women and vice-versa.

4. Data

Like many other studies on education inequality we have used the dataset of Barro and Lee (2015), which covers an impressive set of countries and time periods. The data is based on a compilation of censuses and surveys by UNESCO and provides comparable information on 7 educational attainment categories (no education, primary uncompleted, primary completed, secondary uncompleted, secondary completed, tertiary uncompleted and tertiary completed) for 146 countries during the period 1950-2010. Whenever appropriate, these categories can be reduced to 4 (no education, some primary, some secondary and some tertiary).

We used the estimates from Barro and Lee on educational attainment for the period 1950-2010 without further adjustments. At the same time, we decided to calculate our own projections of future educational attainment using a similar procedure to Barro and Lee's. Calculating our own predictions allowed us to focus on the age group 30-34, instead of the age group 15-64 for which the projections of Barro and Lee were calculated. Selecting this age group enables us to minimize the influence of changes in the age structure within countries on our estimates and at the same time will show the most recent changes in educational attainment. Another motivation has been that some implausible values were observed in the Barro and Lee projections.⁵

Projections

Our projections of future educational attainment are based on a logistic growth curve model estimated for the period 1950-2010 that allows for country-specific time trends (random slopes). The model, estimated separately for men, women, and each of the three educational stages, can be expressed as follows:

$$\ln(s_{j,t}/(100-s_{j,t})) = \alpha_j + \beta_j \text{time} + \mu_{j,t} \quad [10]$$

Where s is the share of the population having attended educational stage j in year t . The coefficient β_j in this case estimates the (linear) time trend in the (logistically transformed) share of the population attending the given educational stage. The model estimates country-specific constants as well as separate coefficients β_j for each country (random slopes in a multi-level model where the two levels are countries and years), so that the predicted educational expansion over time is allowed to follow different trajectories across countries. In this model, countries are expected to eventually approach a 100% attendance for primary and

⁵In some Western countries the attainment of tertiary education for the age group 25-64 was predicted to dramatically decline with time (e.g. Australia, Austria, Finland).

secondary education. It appears unrealistic to expect countries to converge to a 100% attendance of tertiary education. We therefore arbitrarily set a ceiling of 70% for tertiary education. As shown later, predictions using this ceiling fit the data well.

The coefficients from these models are used to project attendance of educational stages for the period 2015-2040. In order to arrive at the 7 educational categories of the historical data, we multiplied attendance shares with the completion rates observed in 2010 for each given country and gender (we multiplied the share of the population that is predicted to attend an educational stage in year t , by ‘share completed in 2010’ / ‘share attended in 2010’).⁶ To safeguard comparability across historical time periods and projections, we decided to present predicted results based on our growth models for all the time period 1950-2040. In the results section we examine the fit of our predicted numbers to actual numbers, which appears to be highly accurate.

5. Empirical findings

In this section we present our empirical findings based on the systematic exploration of the 7 education categories’ distributions that are reported in the Barro and Lee (2015) dataset. We start documenting the global education expansion and the gender gap reversal during the period 1950-2040 using our model predicted data (see section 4). Afterwards, we calculate the corresponding education inequality index and report its values and trends, both globally and regionally, for the same time periods. Then, we analyze the relationship between overall education inequality, its components and the gender gap in education.

Education expansion

Figure 1 presents the share of women having attended primary, secondary, and tertiary education for 7 world regions as well as the predicted shares based on our models. Whereas attendance to primary education was only close to being universal in Advanced Economies and Eastern Europe in 1950, shares close to universality have now reached East Asia and Latin America, and this pattern is expected to extend to South Asia, the Middle East and Africa by 2040. Attendance to secondary education was still a minority phenomenon in all world regions in 1950, but today a majority of individuals in most world regions attends secondary education. In all regions but South Asia and Sub-Saharan Africa more than 90% of women are expected to attend secondary education by 2040. Tertiary education was almost entirely irrelevant in the 1950s but almost half of 30 to 35 aged women are expected to attain tertiary education by 2040 in all regions but Sub-Saharan Africa, where tertiary education is predicted to increase only slowly. Figures for men are similar and displayed in Appendix 1.

For the period 1950-2010, Figure 1 shows both predicted and actual shares of attendance. The fact that the two sets of shares are hardly distinguishable from each other in the graph reflects

⁶In a small set of cases, predicted levels of attending secondary education exceeded predicted levels of primary education attainment by a small margin. To assure that the shares of educational categories eventually summed up to 1, we set attendance of primary education to the level of secondary education attendance.

the good fit of the logistic growth curve models described in the previous section. Only for secondary education in Eastern Europe and primary education in East Asia some differences between both become visible in certain time periods. Due to this relatively neat fit between predictions and reality, we believe that presenting our model-predicted results do not imply a qualitatively important loss of information.

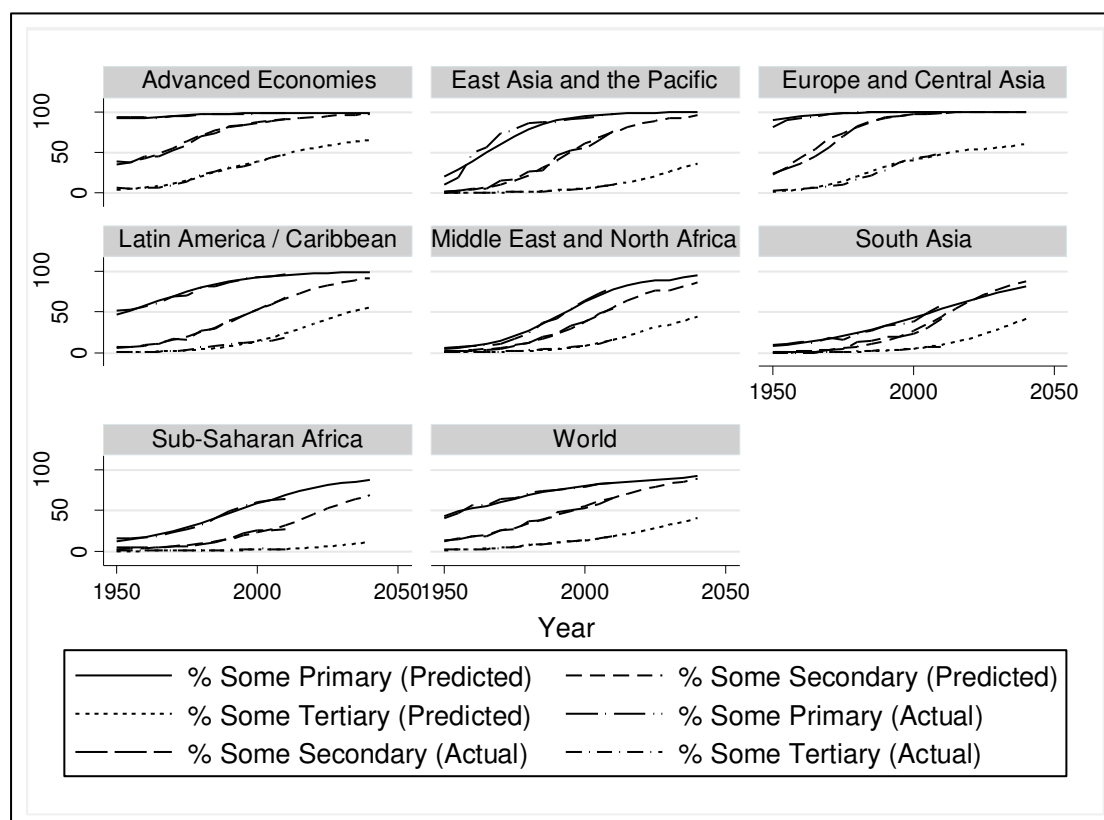


Figure 1. Women's attendance of educational stages 1950-2040, by region, predicted and actual. Weighted by population size of countries.

Gender gap reversal in education

We continue to describe the development of educational attainment over time by presenting our measure of the gender gap in education based on ordinal data. Figure 2 displays, for the 7 world regions as well as for the world overall, how women's educational advantage has developed and is expected to develop across time. Recall that values below 0.5 represent distributions where women are likely to be less educated than men and vice versa. In line with previous research, one can observe that women used to be less educated than men in the past in all world regions, but this gender gap has been reduced dramatically across the globe, and even reversed in Advanced Economies, Eastern Europe, and Latin America. By 2040, the gender gap is expected to be closed and slightly reversed worldwide as well as within almost all world regions (the only exception being Sub-Saharan Africa). Interestingly, these trends

are very similar to the ones reported in Esteve et al (2016), who use completely different sources of data (e.g. different collections of household surveys and census microdata samples).

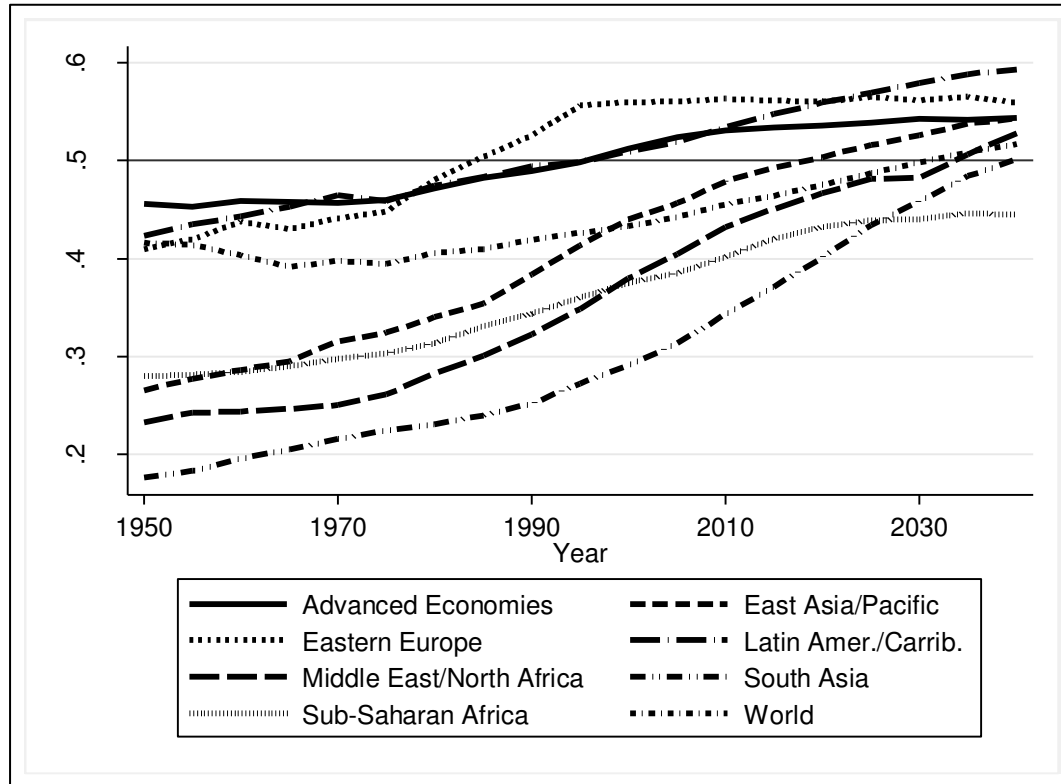


Figure 2. Gender Gap in Education across the period 1950-2040, weighted by country population size.

Evolution of Overall Education Inequality and its components

Figure 3 displays the development of education inequality across the world and within world regions based on ordinal educational categories. It also simultaneously displays the four components of equation 2. The thick solid line represents overall inequality I over time and roughly follows an inverted U-shaped curve worldwide, congruent with the results of Dorius (2013) and Morrisson and Murtin (2013). Each region individually appears to follow a part of that curve during the period under study. In some regions inequality used to be still relatively low in the 1950s, but inequality increased with time and educational expansion. In other regions, inequality was already high but has recently started to decrease slightly. This decrease is expected to continue in the future, and to find its expression in a decline in educational inequality worldwide.

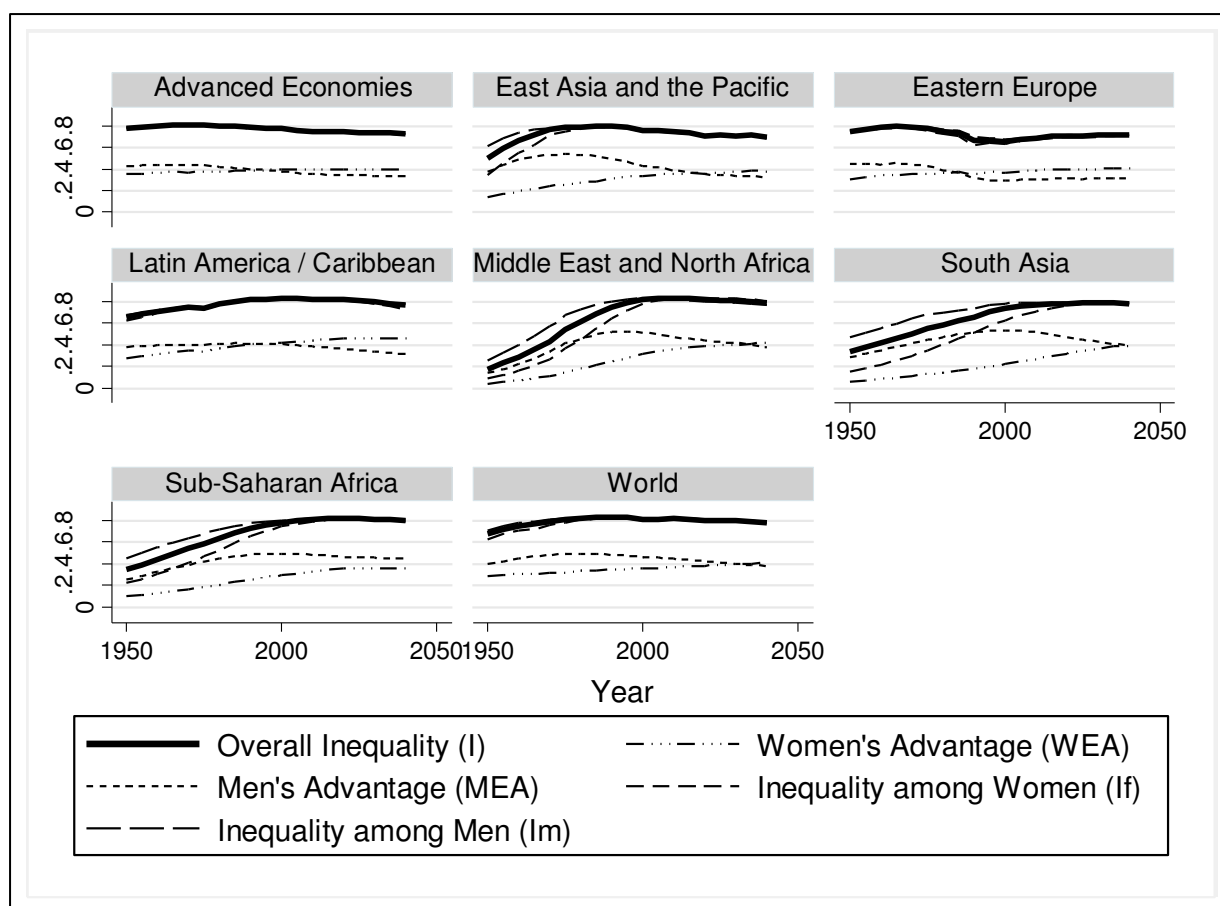


Figure 3. Educational Inequality and its components across time and space, 1950-2040

The other lines of Figure 3 represent educational inequality within the groups of women and men, as well as the two components constituting the gender gap in education. The lines for inequality within the groups of men and women are only visible during the period 1950-2000 and only for a couple of regions, specifically, those with lower levels of education. In those regions inequality in terms of education among women was much lower than inequality among men in the 1950s. By the 2010s, inequality among both men and women became very similar to inequality among all individuals in all regions. This suggests that in the past women used to be a considerably more homogeneous group in terms of education compared to men. Interestingly, despite the reversal in the gender gap observed and its expected persistence in the future, the groups of men and women are expected to remain equally unequal in the period 2010-2040. The educational disadvantage of men therefore does not seem to translate into them being a qualitatively more homogeneous group in terms of education compared to women.

The lines referred to as I_B^f and I_B^m in Figure 3 provide a slightly different representation of gender differences in education across time compared to Figure 2. The numbers show that in all regions of the world it has become increasingly more common to find women who are likely to be higher educated than men in that society. Yet, in some regions (East Asia, South

Asia, Middle East, Sub-Saharan Africa) the increase in men's educational advantage (I_B^m) has been steeper than that of women (I_B^f) from 1950 to 1990 approximately. This implies that in these regions, as education expanded, the potential for unequal interaction between men and women in terms of education was greater in the 1970s-1990s than in the 1950s. This is an observation also made once estimating worldwide inequality in education (the last panel of Figure 3). Such increased potential for unequal interaction in terms of education between men and women might have formed obstacles for increased gender equality in other spheres during that period. This story differs from the conclusion of an ever decreasing gap in education between men and women over time once taking a relative measure of educational differences (e.g. Figure 2, or Barro and Lee, 2015, Chapter 2.6).

Relative Contribution of the Different Components to Overall Education Inequality

Table 1 displays the relative contribution of each of the four components discussed in the previous section to overall education inequality. Back in the 1950s, the educational advantage of men over women was by far the main contributor to education inequality in the world as a whole and in most of its regions (see last column in Table 1). Sixty years later, that contribution has decreased substantially at a global level. Indeed, in several regions (Advanced Economies, Eastern Europe and Central Asia and Latin America and the Caribbean – i.e. in most high- and middle-income countries) it has become the least important contributor to education inequality. Concomitant with these changes, the educational advantage of women over men has become an increasingly important ingredient of overall education inequality (see second-to-last column in Table 1). Sixty years ago, the contribution of that kind of inequality to overall education inequality was by far the least important among the four (particularly so in the poorest regions of the world). Nowadays, women's educational advantage is the main contributor to education inequality in most high- and middle-income countries.

Table 1. Inequality in educational attainment by region and year for 25-29 year-olds, decomposed into within and between women/men components

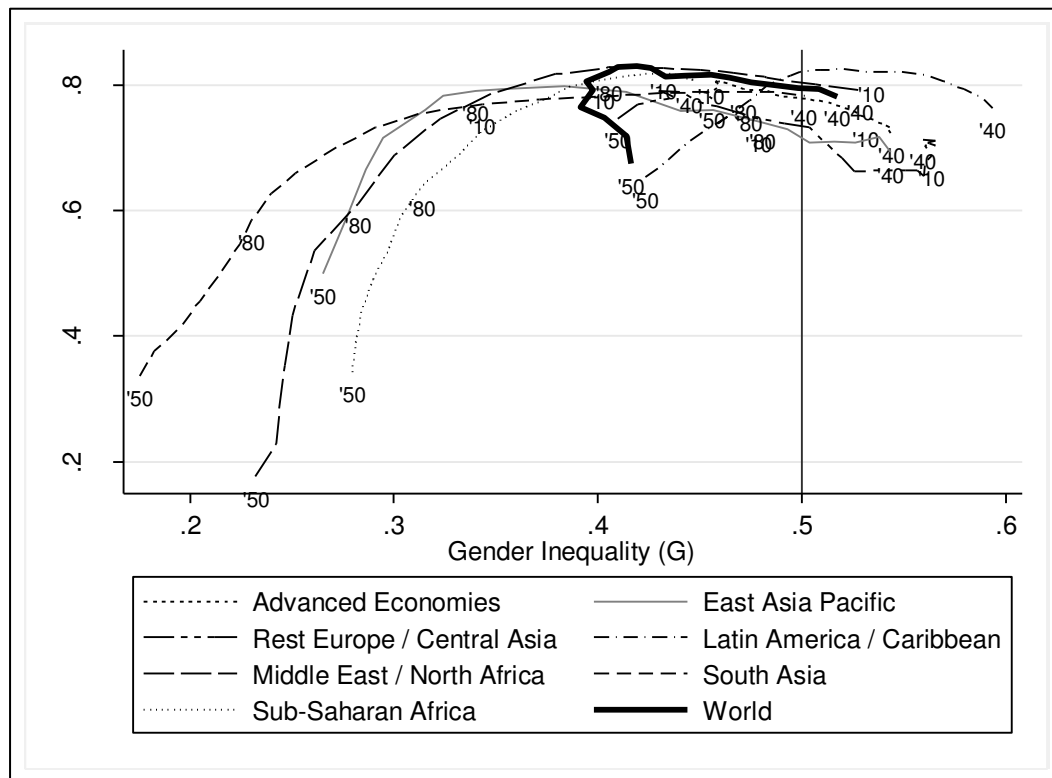
Region	Year	$\%CI_W^f$	$\%CI_W^m$	$\%CI_B^f$	$\%CI_B^m$
Advanced Economies	1950	26.8	23.2	22.8	27.2
Advanced Economies	1980	24.5	25.4	23.6	26.5
Advanced Economies	2010	24.4	25.6	26.6	23.5
Advanced Economies	2040	23.7	26.2	27.2	22.8
East Asia and the Pacific	1950	16.1	32.9	13.5	37.5
East Asia and the Pacific	1980	22.8	26.6	17.2	33.4
East Asia and the Pacific	2010	24.2	25.7	24.0	26.1
East Asia and the Pacific	2040	21.7	28.2	27.2	22.8
E. Europe & Central Asia	1950	33.1	17.8	20.1	28.9
E. Europe & Central Asia	1980	25.6	24.3	24.1	26.0
E. Europe & Central Asia	2010	25.8	24.0	28.3	21.9
E. Europe & Central Asia	2040	23.8	26.1	28.1	22.1
Latin America & Carib.	1950	23.7	26.0	21.3	29.0
Latin America & Carib.	1980	25.1	24.8	23.7	26.3
Latin America & Carib.	2010	25.7	24.2	26.7	23.3
Latin America & Carib.	2040	23.4	26.0	30.0	20.6
Middle E.& North Africa	1950	12.1	37.4	11.7	38.7
Middle E.& North Africa	1980	18.6	29.6	14.6	37.2
Middle E.& North Africa	2010	23.2	26.5	21.7	28.5
Middle E.& North Africa	2040	22.9	26.7	26.6	23.7
South Asia	1950	9.9	38.9	9.0	42.2
South Asia	1980	16.0	31.8	12.0	40.2
South Asia	2010	21.7	27.4	17.5	33.5
South Asia	2040	22.3	27.7	25.0	24.9
Sub-Saharan Africa	1950	16.6	31.9	14.4	37.1
Sub-Saharan Africa	1980	21.2	27.4	16.1	35.3
Sub-Saharan Africa	2010	23.7	26.0	20.2	30.1
Sub-Saharan Africa	2040	24.7	25.2	22.3	27.8
World	1950	23.2	26.5	20.9	29.4
World	1980	23.6	26.1	20.4	29.9
World	2010	24.4	25.5	22.8	27.3
World	2040	23.1	26.9	25.9	24.1

I : Overall inequality; I_W^f, I_W^m : Inequality among women and men respectively; I_B^f/I_B^m : Probability that a randomly selected woman/man is more educated than a randomly selected man/woman; %C: Percent contribution of the different components. Authors' calculations based on Barro and Lee (2013).

The relationship between gender equality and overall inequality

Given these compositional changes, Figure 4 enquires about the relationship between gender (in)equality (as measured by G ; horizontal axis) and overall education inequality (as measured by I ; vertical axis) over time (connected lines). What appears is an inverted U shape, where education inequality is the highest when gender inequality is lowest. In several regions, improvements towards more gender equality have taken place at the expense of

higher overall educational inequality. When gender equality levels are high (values of G around 0.4 and 0.5), overall education inequality is at its peak. In some forerunning regions (Advanced Economies and, to a lesser extent, Latin America and the Caribbean and Eastern Europe/Central Asia) education inequality declines again in tandem with the reversal of the gender gap in education (in this occasion in favor of women). Also here, renewed movements toward more gender inequality thus seem to happen simultaneously with decreasing inequality of education.



Authors' calculations based on Barro and Lee (2013). '50/'80/'10/'40 represent years.

Figure 4. Development of gender and overall inequality in education over time

Given our interest in whether both overall and gender inequality in education could be reduced simultaneously, the question arises whether, despite the regional and global trends, there have been individual countries that have succeeded (or are expected to succeed) in this regard. An inspection of countries' individual trajectories led to the identification of two such scenarios, both depicted in Figure 5. The first trajectory, as exemplified by China, is a simultaneous decline in overall educational inequality and a closing of the gender gap between men and women (other examples of countries that display such trajectories are as varied as Austria, Ghana, Morocco, and Ukraine). In these cases, tertiary education is mostly still at relatively low levels (and is expected to increase only slowly), whereas primary and secondary education reach universality, closing down the gender gap in those levels of education. Some of these countries display an eventual increase in overall educational inequality as tertiary education spreads. The second trajectory, as exemplified by Spain, displays an initial reversal of the gender gap in favor of women, but an eventual (predicted)

decline in both overall and gender equality in education (other examples are Israel, Japan, Norway, Philippines, Russia, and Uruguay). This decline in both types of inequality is due to tertiary education reaching its ceiling, leading men to close the gap with women.

In short, as reducing gender differentials normally requires expanding education (because lowering the attainment of one group could be seen as undesirable), and educational expansion normally also means higher overall inequality in education, closing gender gaps usually results in higher overall education inequality. The exception appears to be when this expansion in education brings the attainment of a certain educational level close to universality, and hence lowers both overall and gender education inequality simultaneously.

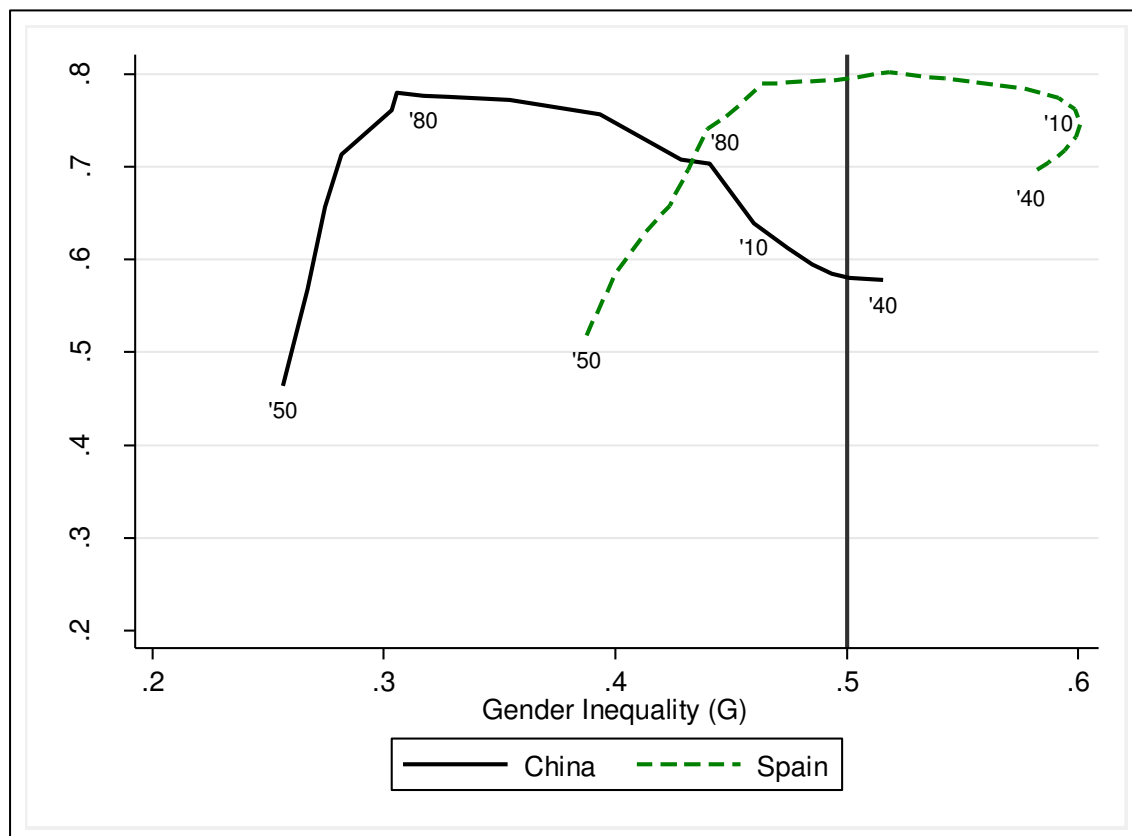


Figure 5. Development of gender and overall inequality in education over time in China and Spain

6. Summary and concluding remarks

The main aim of this research was to investigate the relationship between overall education inequality, its different subcomponents and the gender gap reversal in educational attainment. For that purpose, we have developed a new inequality index with nice decomposability properties adapted to the ordinal nature of educational attainment – a measure that can be a useful addition to the practitioner's toolkit. Based on the Barro and Lee (2015) dataset we have calculated the values of the inequality index and its components for 146 countries during a period spanning almost a century (1950-2040).

An important finding of this research is that after a period of increase concomitant with education expansion, overall education inequality is now declining in the world as a whole and in most of its regions. This finding, based on education as an ordinal variable, is in line with earlier studies based on cardinal variables ('mean years of schooling') (Dorius 2013 and Morrisson and Murtin 2013). While this is a cause of celebration pointing to an increasing equalization of opportunities across citizens worldwide, it is likely that new forms of education inequality might be replacing older ones. Indeed one can suspect that the observed declines in overall education inequality can be attributed to the clustering of the educational attainment distribution at its top, which might be hiding an increasing diversity of superior education alternatives (like Masters and PhDs) not captured in the 7 categories of Barro and Lee's dataset. Some exploratory work carried out for the case of the US using census microdata samples (not shown here but available upon request) suggests that this might be indeed the case. When we enlarge the set of education categories from 7 to 9 (including Masters and PhDs), the decline in overall education inequality is less pronounced.

The decompositions of our new inequality measure into different parts also allowed us to look at inequality among men and women. Women used to be a much more homogeneous group compared to men in terms of education in several world regions in the past. This increased heterogeneity in education could lead to more variation in terms of interests within the group of women. One could expect the opposite trend for men as the gender gap in education reverses and increasingly favors women. However, our results showed that inequality among men and women is now equally unequal in all world regions, and this is expected to remain so in the near future.

Back in the 1950s, the educational advantage of men over women was by far the main contributor to education inequality in the world as a whole and in most of its regions, while the opposite was true about the educational advantage of women over men. Nowadays, men's educational advantage has become the least important contributor to education inequality in several regions, while women's educational advantage is the main contributor to education inequality in most high- and middle-income countries. Intuitively one would expect that as the educational attainment of women and men become increasingly similar, overall education inequality would decrease. The results of this paper showed that on first sight this does not appear to be the case. On the contrary, as our gender inequality measure G approaches the equality threshold of 0.5, the corresponding education inequality levels approach their highest levels. In addition, when the gender gap reverses in favor of women (thus increasing our

gender inequality measure), overall education inequality is lower. Assuming that the educational advantage of one sex over the other is normatively undesirable, our findings suggest that there might be difficult trade-offs between gender and overall education inequality, as they both seem to run in opposite directions. If further education expansion contributes to further decreases in overall education inequality *and* increases in females' educational advantage over men (a scenario that appears likely until a ceiling of tertiary education attainment is reached in many countries), it will be essential to understand under which conditions tension between both policy objectives can be minimized.

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Appendix 1. Actual and predicted attendance of educational stages for men 1950-2040

